Appendix A
Chapter 1: Methodology for Economic Impact Analysis

Graphic No. 1 illustrates a simplified framework to characterize the economic development impact of a given sector of the economy:

- **Direct Output** is a broad measure of the value of goods and services that can be directly attributed to the sector.
- **Indirect Output** accounts for the changes in inter-industry transactions as supplying industries respond to increased demands from the directly affected sectors.
- **Induced Output** reflects the impact of increased consumer spending resulting from income changes in the directly and indirectly affected sectors.

For simplicity, and given the preliminary nature of this analysis, economic impacts are quantified through the two most intuitive and widely adopted metrics:

- Direct Output (specifically the portion that remains in the local economy), and
- Direct Jobs Created.

Preliminary estimates for indirect and induced economic impacts are also presented based on "multiplier effects" that have been estimated (not for this specific project) using the IMPLAN[1] model in the context of Massachusetts.

For the purpose of this work, it is necessary to distinguish between two very different parts ("value chains") of the advanced biofuels sector:

- **Operational Deployment:** this includes all the activities associated with the construction and operation of advanced biofuels facilities such as engineering and construction, feedstock and biofuels production and logistics, maintenance, and operation support.
- **Technology Development:** this includes all the activities associated with research, development and commercialization of "advanced" technologies.

Graphic No. 2 (on the following page) illustrates schematically the sequence of activities (which will be referred to as segments of the value chains) that characterize both areas of activity within the sector.

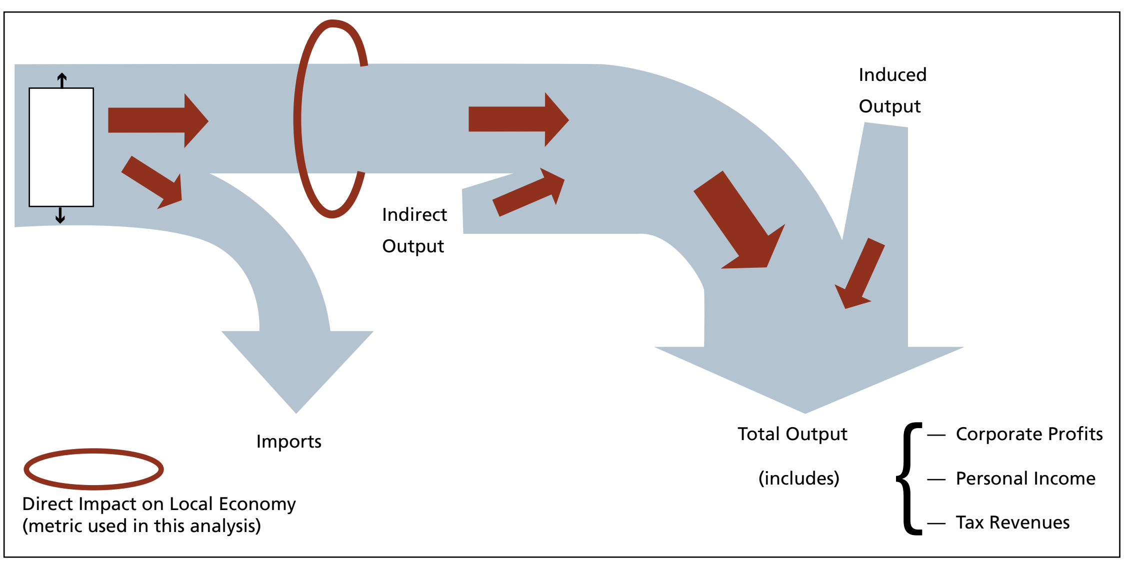
Economic benefits are broken down among the segments of each value chain. In the case of the operational deployment value chain, the segments identified in Graphic No. 2 correspond, broadly, to the following four sectors of the economy: construction; forestry, agriculture and waste management; industrial processing; and downstream oil and gas.

Scenarios for Feedstock Availability and Advanced Biofuels Production Potential

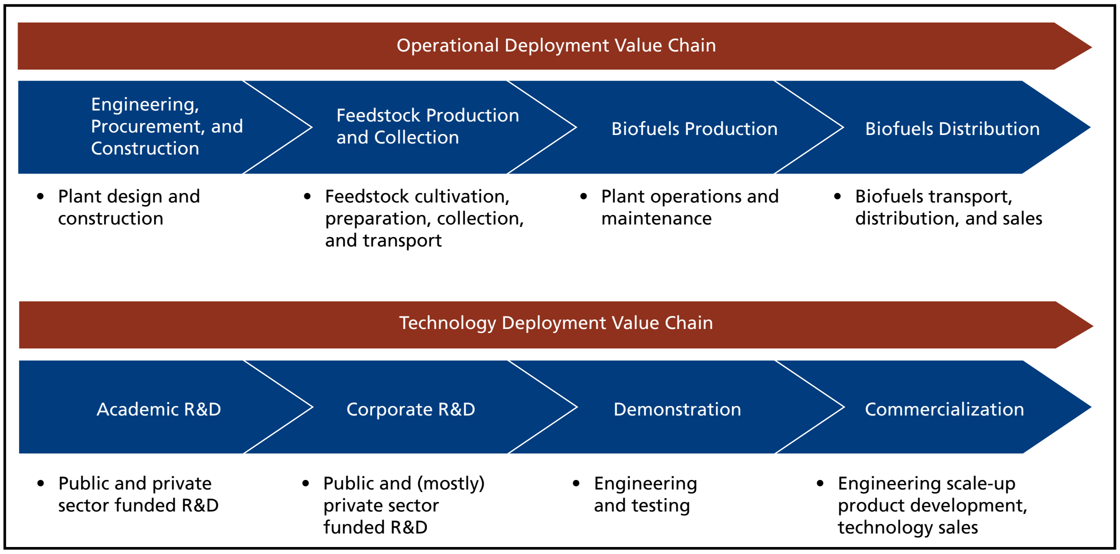
- Low Production Scenario
- General Characterization: weak policy support and marginal technology improvements
- Feedstock Supply: 1.6 MBDT per year (Million Bone Dry Tons per year) @ $20 per BDT[2]

1 The IMPLAN (Impact Analysis for Planning) model is a commonly used software package and database for estimating local economic impacts. Details at: http://edis.ifas.ufl.edu/FE168. Indirect and induced economic impacts are provided as a multiplier of direct output.

2 Price sensitivities based on ORNL study "Estimated Annual Cumulative Biomass Resources Available by State and Price", March 12, 1999.



Graphic No. 1: Characterization of Economic Impacts



Graphic No. 2: Advanced Biofuels Value Chain

- Advanced Biofuels Produced: 100 MGPY (Million Gallons of Gasoline Equivalent, or GGE, per year) at a yield of 60 gallons per dry ton

Medium Production Scenario

- General Characterization: strong policy support and technology breakthroughs; competition for feedstock with other applications (power, bio-based products)
- Feedstock Supply: 2.5 MBDT per year @ $35 per BDT
- Advanced Biofuels Produced: 200 MGPY @ 80 gallons per ton

High Production Scenario

- General Characterization: strong policy support and technology breakthroughs; limited competition for feedstock with other applications (power, bio-based products)
- Feedstock Supply: 3.7 MBDT per year @ $50 per BDT
- Advanced Biofuels Produced: 380 MGPY @ 100 gallons per ton

The following are some important considerations on biomass feedstock availability in the State as outlined in Table 2 of Chapter 1:

- These figures include some feedstocks that are currently used or recycled (such as primary mill residues and waste paper) when prices for biofuels feedstock are assumed adequate to divert this material from its current use.
- The key biomass feedstock sources in the state for biofuels production are from urban wastes. This includes categories such as construction and demolition wood, yard trimmings and the organic fractions of municipal solid waste. A high-level approach was used in this analysis, by which the collection and delivery of this feedstock to an advanced biofuels facility generates direct economic output based on the price that the biofuels facility can pay for such feedstock (regardless of how this economic value is then distributed between the different players involved such as municipalities, waste management companies, haulers, etc). However, the real implications of diverting what are currently waste streams are far-reaching and may deserve an analysis beyond the scope of the current work. For example, today municipalities pay a tipping fee for the disposal of waste to waste management firms when the material is not recycled. These transactions would be materially changed in the scenarios discussed in this analysis, with some players and sectors benefiting more than others from the economic impacts of advanced biofuels

Potential Economic Impacts of Advanced Biofuels Technology Development

The following points illustrate the potential economic impacts of advanced biofuels technology development, measured as direct output, for a range of scenarios:

Table A.1: Distribution of direct economic impacts across the operational deployment value chain			
	Distribution of Economic Impacts		
	% Value	% Incremental	% Local
Engineering, Procurement & Construction	12%	100%	30%
Feedstock Production and Collection	44%	100%	80%
Biofuels Production	38%	100%	50%
Biofuels Distribution	6%	50%	80%

- Global market for advanced biofuels by 2025: 50 BGPY (billion GGE per year)[3]
- Royalty payment: $0.05-0.08 per gallon[4]
- Percent of market for Massachusetts-based companies: 10-15%[5]
- Percent of royalty value that stays in the local economy: 50-75%[6]

Assumptions for Economic Impact Analysis

Table A.1 summarizes the assumptions that were made to calculate the incremental economic impact to Massachusetts that can be attributed to this sector.

- The majority of the value is concentrated in the "Feedstock Production and Collection" and "Biofuels Production" segments of the value chain.[7] This reflects the fact that initial capital costs for biofuels operations, even those employing advanced technologies, represent a smaller fraction of total lifecycle costs than feedstock and processing (especially when compared with other renewable energy technologies).
- Construction activities are spread out evenly over a 15 year period, although actual construction would likely be more erratic over the period in which the industry is developing.
- Other than for biofuels distribution, the economic value of the sector to the state is assumed to be entirely incremental, reflecting the fact that all fossil fuels currently used in the state are imported. By displacing imports, biofuels can partly reverse this economic outflow, "injecting" it into the local economy. For biofuels distribution, 50% of the value generated in the state is assumed to be incremental, with the remainder merely replacing lost economic activity to the state related to the distribution of displaced petroleum fuels.[8]
- The portion of direct economic activity stimulated that will remain in the state has been estimated for each segment of the value chain. This is based on common sense assumptions, as well as publicly available databases and studies.[9] One important consideration relates to biofuels production - the thermal energy as well as electricity requirements of the operation (which together may make up a substantial portion of the overall production costs) are assumed to be provided by waste biomass and do not require the use of fossil fuels.
- Direct impacts are converted into total impacts using rough estimates of the economic "multipliers" for output (1.9, meaning that for each dollar of direct spending 0.9 dollars of indirect and induced spending result) and for employment (2.3, meaning that for each direct job, 1.3 indirect/induced jobs are created). These estimates are based on a "high-level" review of economic sectors relevant to the biofuels industry.
- For construction, direct employment estimates were used to estimate economic impacts by assuming that each job is associated with $150,000 in direct spending.

3 The World Energy Outlook (published by the International Energy Agency) calls for 52 BGPY of Advanced Biofuels globally by 2030 in its Alternative Policy Case. The latest Energy Bill passed by the U.S. legislature (December 2007) contains a provision (RFS: Renewable Fuel Standard) mandating the use on 21 BGPY of Advanced Biofuels by the year 2022.

4 This represents ~2-5% of the full projected cost of (mature) Advanced Biofuels. As a royalty payment, this percentage is lower than what is typical in other sectors (for example biotechnology and pharmaceuticals), reflecting the competitive nature of energy commodity markets.

5 Massachusetts companies are currently at the forefront of technology development in the sector.

6 Some of the economic value will "leak out" of the local economy in the form of purchases of goods and services and partnerships with out-of-state technology providers and academic institutions.

7 Distribution of direct output across the value chain is based on assumed transfer prices, construction and O&M costs. Biomass cost of $50/dry ton delivered (http://bioenergy.ornl.gov/resourcedata/index.html); transportation to wholesale terminal has a value of $0.10-0.15/GGE. Yields, construction and O&M costs are based on NCI estimates and publicly available studies such as the NREL study: "Lignocellulosic Biomass to Ethanol Process Design and Economics" (http://www.nrel.gov/docs/fy02osti/32438.pdf). Value of biofuels production includes refining margins.

8 The analysis assumes that the "lost" economic value from petroleum displacement (wholesale distribution) is of $0.05-0.07/GGE, or 50% of the economic value of biofuels distribution (i.e. distribution of biofuels from the plant to the wholesale terminal is less efficient than that of petroleum). Additionally, the analysis "finishes" at the wholesale terminal: beyond that, all the value created in the retailing of biofuels merely replaces the value lost from displacing petroleum and is not incremental.

9 Value of "Feedstock Production and Collection" and "Biofuels Distribution" is assumed to remain mostly in-state given the local nature of these activities (some imports would take place in the form of equipment, etc.). EPC services are instead mostly imported as the State is assumed to have limited companies operating in this specific segment. 50% of the value generated by the conversion of biomass to biofuels is assumed to exit the economy through imports of materials (chemicals, enzymes, etc); the other 50% would remain in the local economy in the form of labor, O&M, refining margins. Figures are based on NCI estimates and previous applications of the IMPLAN model: http://www.eere.energy.gov/windandhydro/windpoweringamerica/filter_detail.asp?itemid=707

Table A.2: Direct job creation—key assumptions			
Value Chain Segments	Jobs Created Per Million Gallons/Year		
	Low	High	Comment
Engineering, Procurement & Construction	30	40	Temporary
Feedstock Production and Collection	2	2.5	Permanent
Biofuels Production	1.5	2	Permanent
Biofuels Distribution12	0.25	0.5	Permanent

Table 2 outlines job creation assumptions based on a review of publicly available literature.[10] As was done for direct output, job creation has also been estimated for each of the four segments of the operational deployment value chain. Engineering, procurement and construction jobs are considered temporary in nature (created only during the plant construction phase), while all other steps will generate permanent jobs

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Appendix B
Chapter 5: Fuel Infrastructure

Major New England Petroleum Terminals - MA				
Sources: 2007 OPIS/Stalsby Petroleum Terminal Encyclopedia and MA DOER Surveys				
Location	Terminal	Products Stored	Tank Capacity	Exchange/Throughput Partners
		Ethanol		
Braintree	Citgo Petroleum	Ethanol	176,500	ExxonMobil (XOM)
Chelsea	Gulf Oil	Ethanol	115,122	
East Boston	ConocoPhillips	Ethanol	74,585	ExxonMobil, Epic Aviation,
Revere	Global Petroleum	Ethanol	80,000	
Revere	Irving Oil	Ethanol	112,000	
Springfield	ExxonMobil	Ethanol	9,953	Texaco, XOM
			568,160	
		Regular & Premium Gasoline		
Braintree	Citgo Petroleum	Unleaded Gasoline	594,000	Hess, Gulf, Sprague,
Braintree	Citgo Petroleum	Premium	123,000	Sunoco, Valero,
Chelsea	Gulf Oil	RBOB	444,680	
Chelsea	Gulf Oil	PBOB	75,250	
East Boston	ConocoPhillips	RBOB Gasoline	303,776	New England Petroleum,
East Boston	ConocoPhillips	PBOB Gasoline	56,170	Bosfuels, Hess,
Everett	ExxonMobil	Gasoline (inc. ethanol)	627,000	Througput: Valero
Revere	Global Petroleum	Reg. Unleaded gas	635,000	
Revere	Global Petroleum	Premium gasoline	80,000	
Revere	Irving Oil	Gasoline	471,000	
Springfield	ExxonMobil	Gasoline	157,000	Gulf, Hess, Shell, Sunoco,
			3,566,876	
		On-road/Off-road Diesel		
Chelsea	Global Petroleum	Ultra low diesel	32,000	
East Boston	ConocoPhillips	Diesel	46,161	Gulf/Cumberland Farms,
Everett	ExxonMobil	ultra low sulfur diesel	185,000	Irving, Getty
Revere	Global Petroleum	ultra low diesel	100,000	
Sandwich	Global Petroleum	ultra low diesel	30,000	
Springfield	ExxonMobil	ultra low sulfur diesel	29,020	Citgo, ConocoPhillips,
Springfield	Springfield Terminals	ultra low sulfur diesel	45,238	Global Petroleum
			467,419	
		#2 Oils		
Braintree	Citgo Petroleum	#2 ultra low sulfur	198,000	
Braintree	Citgo Petroleum	#2 heating oil	306,500	
Chelsea	Global Petroleum	#2 High sulfur diesel	280,000	Global
Chelsea	Gulf Oil	#2 heating oil	369,493	none
Chelsea	Gulf Oil	#2 ultra low sulfur	126,980	
Everett	ExxonMobil	#2 High sulfur diesel	531,000	Exch: Shell (Motiva)
Everett	ExxonMobil	#2 Low sulfur diesel	0	ConocoPhillips, Gulf
New Bedford	Sprague	#2 High sulfur diesel	55,851	Global
Quincy	Sprague	#2 High sulfur diesel	220,000	ExxonMobil, Motiva
Quincy	Sprague	#2 Low sulfur diesel	91,000	
Quincy	Sprague	#2 ultra low sulfur	91,000	
Quincy	Sprague 2	#2 oil	154,000	ExxonMobil
Quincy	Sprague 2	#2 ultra low sulfur	94,000	
Revere	Global Petroleum	#2 High sulfur oil	963,000	Citgo, Getty, Sunoco
Revere	Global Petroleum	#2 Low sulfur diesel	150,000	
Revere	Irving Oil	#2 oil	155,000	?
Revere	Irving Oil	#2 Low sulfur diesel	100,000	
Sandwich	Global Petroleum	#2 High sulfur diesel	70,000	Global
Springfield	Global Petroleum	#2 oil	50,000	
Springfield	L.E. Belcher	#2 Low sulfur diesel		
Springfield	Springfield Terminals	#2 oil	50,000	
			4,055,824	
		#4, #6 & Heavy Oils		
Chelsea	Global Petroleum	#6 Residual fuels	373,000	
Everett	ExxonMobil	residual oil	505,000	
Everett	Sprague	Asphalt	429,000	
New Bedford	Sprague	Light Cycle Oil	30024	
New Bedford	Sprague	#6 Residual fuels	162,180	
Quincy	Sprague	residual oil	78,000	
Springfield	Springfield Terminals	heating oil		
			1,577,204	
		Kerosene, Jet Fuel, Additives and Other		
Braintree	Citgo Petroleum	Additives	1,469	
East Boston	ConocoPhillips	Jet A fuel	502,080	(several partners)
Quincy	Sprague	kerosene	78,000	
Quincy	Sprague	jet fuel	62,000	
Quincy	Sprague 2	caustic soda	25,000	
Revere	Global Petroleum	ultra low kero	80,000	
Springfield	L.E. Belcher	K-1 Kerosene		
Springfield	Springfield Terminals	kerosene	10,048	Global
			758,597	

Appendix C
Advanced Biofuels Task Force – Oral and Written Testimony

Alexander, Jack – Entergy

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Burke, Ed – Dennis K. Burke, Inc

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Federspiel, Greg – Town of Lenox

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Garrity, Robert – Massachusetts Climate Action Network (MCAN)

Glick, Lilah – Clean Water Action

Greene, Nathanael – Natural Resources Defense Council (NRDC)

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Leue, Tom – Homestead Inc

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Long, Stephen – The Nature Conservancy

Maruiello, Lauren

McDiamond, Jeremy – Environment Northeast

Mead, Joe – World Energy

Nasiff, Steve – Maine Biofuel LLC

Quinn, John – American Petroleum Institute

Quint, Eliot – Global Partners

Rennicke, Michael – Pioneer Valley Railroad

Riva, Carlos – Verenium Corporation

Rogers, John – Union of Concerned Scientists

Schoetzel, Tyson – Homestead, Inc.

Schofield, Clay – Cape Cod Commission

Schuyler, Andrew – Northeast Biofuels Collaborative

Schwarz, Robert – Peter Pan Bus Lines

Sharp, Jef – Sunethanol

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Sperling, Daniel – University of California, Davis

Spitzer, Jeremie – Greasecar Vegetable Fuel Oil

Stein, Richard – University of Massachusetts, Amherst

Swirk, Dave – Pioneer Valley Railroad

Union, Lawrence – Northeast Biodiesel

Vale, Shanna – Conservation Law Foundation

Wilke, Mike

Wright, Ben – Environment Massachusetts

Wysocki, Ted – SMF Consulting

Young, Corrine – Bionergy International

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National Biodiesel Board http://www.biodiesel.org/

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Appendix E
Other State Policies

Other states have active biofuels programs and incentives. For the most up-to-date descriptions and comparisons of programs see the U.S. Department of Energy's Alternative Fuels and Advanced Vehicles Data Center web page at:

http://www.eere.energy.gov/afdc/incentives_laws.html

Appendix F
Advanced Biofuels Task Force Scoping Document from Governor Deval L. Patrick, Senate President Therese Murray and Speaker of the House Salvatore F. DiMasi

There shall be a task force to study and make recommendations for legislation to promote the development of an advanced biofuels industry in the Common-wealth. The task force shall develop a strategic framework to accelerate the development and deployment of commercially viable advanced biofuels, and facilitate expansive biofuel research throughout the Commonwealth. Said strategic framework shall include, but shall not be limited to, the following: (i) promoting infrastructure for cellulosic feedstock delivery to processing plants and for the distribution of ethanol to motor fuel distributors; (ii) developing a regulatory and legislative framework to expedite siting and permitting of ethanol or bio-diesel manufacturing or distribution facilities within the Commonwealth; (iii) analyzing the energy and environmental lifecycle of advanced biofuels; (iv) fostering the development of a market for energy crops; (v) tax incentives and research grants to identify and promote the development of domestic feedstocks and technologies necessary to manufacture advanced biofuels in the commonwealth, and (vi) regulatory and legislative actions intended to promote increased reliance on ethanol as an ingredient for fuel in Massachusetts.

The task force shall also consider existing barriers to the development and implementation of advanced biofuels as an increasing part of the fuel mix, legislative or administrative actions to overcome those barriers, and the availability of federal grants to assist in the development of advanced biofuels. The task force shall be comprised of three members of the Senate, two appointed by the president of the Senate and one appointed by the minority leader of the Senate; three members of the House, two appointed by the speaker of the House and one appointed by the minority leader of the House; and three members appointed by the Governor, one of whom shall be the Secretary of Energy and Environmental Affairs or his designee, who shall chair the task force, and one of whom shall be employed by a company that works in the field of advanced biofuels. In developing its recommendations, the task force shall consult with the New Fuels Alliance and at least one distributor of petroleum products domiciled in Massachusetts. The task force shall hold no fewer than four hearings, at least one of which shall be in western Massachusetts and at least one of which shall be in southeastern Massachusetts. The task force shall file a report of its findings and recommendations with the Governor and with the clerks of the House and Senate no later than March 31, 2008.

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Glossary of Terms

Advanced or second-generation biofuels – defined in the new federal energy law as any fuel, except corn-based ethanol, that yields at least a 50% lifecycle reduction in greenhouse gas emissions compared with petroleum fuel. Advanced biofuels are generally fuels that are not made from food crops, but are instead derived from cellulosic-based or biomass materials.

ASTM – ASTM International, originally known as the American Society for Testing and Materials, a private-sector standards development organization that develops voluntary technical standards for materials, products, systems and services.

Biodiesel – a fuel made by chemical processing of vegetable oils and other fats. It can be used either in pure form or as an additive blended with petroleum-based diesel fuel, and contains about as much energy per gallon as petroleum diesel. At low blends, such as 5% (called B5), and possibly at higher blends, it can be used in both vehicle engines and heating equipment without requiring equipment changes.

Biofuel – a fuel produced from any organic matter that is available on a renewable or recurring basis, including plant biomass, vegetable oils and other non-hazardous waste materials such as greases. Types of biofuels include ethanol, biobutanol, biodiesel, hydrogenation-derived fuels, and biogas.

Biomass – any biological materials; generally solids such as cellulosic organic materials, plant or algal matter, animal wastes or byproducts, agricultural crops or crop byproducts and wood materials or wastes.

Biorefinery – any facility that produces a product such as fuel, heat, or power from bio-based materials.

Cellulosic fuels – liquid fuel, such as cellulosic ethanol, derived from plant materials that are generally inedible, consisting largely of lignin, cellulose and hemicellulose – the main constituents of cell walls in most plants. For example: the stalks of food crops that remain after the edible portions have been removed; or post-consumer, commercial organic residues that are available on a renewable or recurring basis. Once they are commercially available, cellulosic fuels are expected to yield substantially better lifecycle reductions in greenhouse gas emissions than first-generation biofuels such as corn-based ethanol. In the federal energy law, cellulosic fuel must reduce greenhouse gas emissions by at least 60% in comparison with petroleum fuel.

Ethanol – a form of alcohol, also known as ethyl alcohol, that can be derived from crops such as corn and sugar via fermentation. In the United States, almost all ethanol is derived from corn, while in Brazil the main source is sugar. Providing about 30% less energy per gallon than gasoline, it is most commonly used in the United States in a blend containing 10% ethanol and 90% gasoline, called E10, which helps to reduce air pollution and is sold as regular gasoline.

Feedstock – material that is used as a source for conversion into a fuel, such as corn, soy, wood, switchgrass, or organic waste materials.

First-generation biofuels – generally, non-petroleum fuels derived from food crops, especially ethanol derived from corn. In the federal energy law passed in December 2006, they are defined as fuels that yield less than a 20% reduction in greenhouse gas emissions over their lifecycles, in comparison with the petroleum fuel that they would replace.

Greenhouse gas emissions – emitted gases that trap heat in the atmosphere, thereby contributing to global climate change. Carbon dioxide, or CO_2, is the predominant greenhouse gas, produced by the combustion of any carbon-containing material, including both fossil fuels (oil, gas, coal) and renewable organic materials such as wood or ethanol. Other greenhouse gases include methane and nitrous oxide.

Lifecycle greenhouse gas emissions – in the context of this report, emissions which occur not only when a fuel is burned, but which result from the entire lifecycle of creating and using a fuel. For petroleum fuel, this would include exploring for oil, drilling and extracting oil, and transporting it to end use points. For biofuels, it includes emissions from manufacturing and running farm machinery, producing fertilizers and pesticides, and processing crops into ethanol or biodiesel. Recently, it is also being defined to include indirect impacts that take place if the use of crops for fuel instead of food causes conversion of additional forest or grassland into crop land.

Low Carbon Fuel Standard (LCFS) – a Low Carbon Fuel Standard is currently being developed in California, where it was instituted by executive order of the governor as one part of achieving the state's overall commitment to reduce greenhouse gas emissions. The LCFS mandates that the "carbon intensity" – lifecycle greenhouse gas emissions per unit of energy delivered – of vehicle fuel in California be reduced 10% by 2020. All methods of powering vehicles would be eligible for the LCFS – not only liquid fuels, but also all-electric vehicles, plug-in hybrids, and hydrogen fuel cells. The LCFS would not require every gallon of fuel used in the state to have 10% lower carbon content, but instead that the average of all fuel used in the state would be 10% lower. Thus, a fuel distributor could meet the requirement by selling some cellulosic ethanol while continuing to sell mostly gasoline, or by buying "carbon credits" from other distributors who have reduced their average emissions by more than 10%.

Renewable – a resource that can be regrown, in contrast to fossil fuels which are in fixed supply (making them non-renewable).

Advanced Biofuels Task Force

Commonwealth of Massachusetts

Deval L. Patrick, Governor

Therese Murray, Senate President

Salvatore F. DiMasi, Speaker of the House

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